UNIT # 1
PHYSICAL QUANTITIES AND MEASUREMENT

Q1. Define Science?

Ans: Science:

The knowledge gained through observations and experimentations is called Science. The word science is derived from the Latin word *scientia*, which means knowledge. Not until eighteenth century, various aspect of material objects were studied under a single subject called natural philosophy.

Q2. Describe the division of science into two main streams?

Ans: Division of science:

As the knowledge increased, it was divided into two main streams;

i. Physical sciences:

Physical sciences - which deal with the study of non-living things.

ii. Biological sciences:

Biological sciences - which are concerned with the study of living things.

Q3. Define Physics?

Ans: Physics:

Physics is that branch of science which deals with the study of properties of matter energy and their mutual relationship.

Q4. Describe the different branches of physics?

Ans: Branches of physics:

i. Mechanics:

It is the study of motion of objects, its causes and effects.

ii. Heat:

It deals with the nature of heat modes of transfer and effects of heat.

iii. Sound:

It deals with the physical aspects of sound waves, their production, properties and applications.

iv. Light (Optics):

It is the study of physical aspects of light, its properties, working and use of optical instruments.

v. Electricity and Magnetism:

It is the study of the charges at rest and in motion, their effects and their relationship with magnetism.

vi. Atomic Physics:

It is the study of the structure and properties of atoms.

vii. Nuclear Physics:

It deals with the properties and behaviour of nuclei and the particles within the nuclei.

viii. Plasma Physics:
It is the study of production, properties of the ionic state of matter - the fourth state of matter.

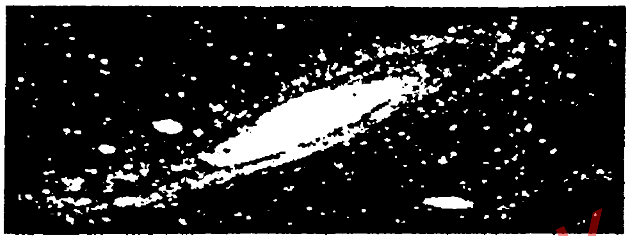
ix. Geophysics:
It is the study of the internal structure of the Earth.

Q5. Describe the Lord Kelvin statement?

Ans: Kelvin statement:

When you can measure what you are speaking about and express it in numbers, you know something about it. When you cannot measure what you are speaking about or you cannot express it in numbers, your knowledge is of a meager and of unsatisfactory kind.

FOR YOUR INFORMATION



Andromeda:
Andromeda is one of the billions of galaxies of known universe.

Q6. Describe the crucial role of physics in science, technology and society?

Ans: Crucial role of physics in science, technology and society:

The rapid progress in science during the recent years has become possible due to the discoveries and inventions in the field of Physics. The technologies are the applications of scientific principles. Most of the technologies of our modern society throughout the world are related to Physics.

Examples:

i. A car is made on the principles of mechanics and a refrigerator is based on the principles of thermodynamics.

ii. Consider pulleys that make it easy to lift heavy loads.

iii. Electricity is used not only to get light and heat but also mechanical energy that drives fans and electric motors etc.

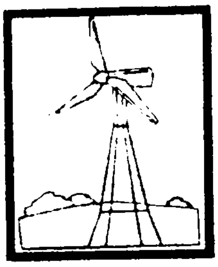
iv. Consider the means of transportation such as car and aero planes; domestic appliances such as air-conditioners, refrigerators, vacuum-cleaners, washing machines, and microwave ovens etc.

v. Similarly the means of communication such as radio, TV, telephone and computer are the result of applications of Physics. These devices have made our lives much easier, faster and more comfortable than the past.

vi. Mobile phone allows us to contact people anywhere in the world and to get latest worldwide information. We can take and save pictures, send and receive messages of our friends. We can also receive radio transmission and can use it as a calculator as well.

Q7. List the harmful effects of the scientific inventions on nature?

Ans: The scientific inventions have also caused harms and destruction of serious nature. One of which is the environmental pollution and the other is the deadly weapons.



DO YOU KNOW?

Wind turbines are used to produce pollution free electricity.

Quick Quiz

1. Why do we study physics?

Ans: We study physics because Physics is the branch of science which deals with the matter, energy and their interaction. Most of the technologies of our modern society throughout the world are related to physics.

2. Name any five branches of physics?

Ans: **i.** Mechanics **ii.** Thermodynamics **iii.** Electromagnetism **iv.** Atomic Physics **v.** Plasma Physics

Q8. Explain with examples that science is based on physical quantities which consist of numerical magnitude and a unit.

Ans: Physical Quantities:

All measurable quantities are called physical quantities such as length, mass, time and temperature.

A physical quantity possesses at least two characteristics in common. One is its numerical magnitude and the other is the unit in which it is measured.

Measuring Height

Examples:

For example, if the length of a student is 104 cm then 104 is its numerical magnitude and centimeter is the unit of measurement.

Similarly when a grocer says that each bag contains 5 kg sugar, he is describing its numerical magnitude as well as the unit of measurement. It would be meaningless to state 5 or kg only.

Physical quantities are divided into base quantities and derived quantities.

Q9. What is the difference between base quantities and derived quantities? Give three examples in each case.

Ans: See Q # 1.2 from Exercise.

Q10. Define unit?

Ans: Unit:

Once a standard is set for a quantity then it can be expressed in terms of that standard quantity. This standard quantity is called a unit.

Q11. List the seven units of System international (SI) along with their symbols and physical quantities?

Ans: International system of units:

The eleventh General Conference on Weight and Measures held in Paris in 1960 adopted a world-wide system of measurements called International System of Units. The International System of Units is commonly referred as SI.

Base units:

The units that describe base quantities are called base units. Each base quantity has its SI unit. Table shows *seven* base quantities, their SI units and their symbols.

Base quantities, their SI units with symbols

Quantity		Unit	
Name	**Symbol**	**Name**	**Symbol**
Length	l	metre	m
Mass	m	kilogramme	kg
Time	t	second	s
Electric current	I	ampere	A
Intensity of light	L	candela	cd
Temperature	T	kelvin	K
Amount of a substance	n	mole	mol

Q12. What are the main advantages of system international (SI units)?

OR

Why do we prefer SI units?

Ans: **i.** SI system is in use all over the world.

ii. Manipulation in this system is quite easy i.e. the multiple and sub multiple of different units are obtain simply by multiplying or dividing with ten or powers of tens.

Q13. Explain with examples the derived units?

Ans: Derived units:

The units used to measure derived quantities are called derived units. Derived units are defined in terms of base units and are obtained by multiplying or dividing one or more base units with each other.

Examples:

i. The unit of area $(\text{meter})^2$ and the unit of volume $(\text{meter})^3$ are based on the unit of length, which is meter. Thus the unit of length is the base unit while the unit of area and volume are derived units.

ii. Speed is defined as distance covered in unit time; therefore its unit is meter per second. In the same way the unit of density, force, pressure, power etc. can be derived using one or more base units.

Derived quantities and their SI units with symbols

Quantity		Unit	
Name	**Symbol**	**Name**	**Symbol**
Speed	v	metre per second	ms^{-1}
Acceleration	a	metre per second per second	ms^{-2}
Volume	V	cubic metre	m^3
Force	F	newton	N or (kg m s^2)
Pressure	P	pascal	Pa or (N m^{-2})
Density	ρ	kilogramme per cubic metre	kgm^{-3}
Charge	Q	coulomb	C or (As)

Quick Quiz

1. How can you differentiate between base and derived quantities?

Ans: Difference between base and derived quantities:

Base Quantities	Derived Quantities
i. Base quantities are the quantities on the basis of which other quantities are expressed.	**i.** The quantities that are expressed in terms of base quantities are called derived quantities.
ii. Length, mass, time, electric current, temperature, intensity of light and the amount of a substance.	**ii.** Area, volume, speed, force, work, energy, power, electric charge, electric potential, etc.

2. Identify the base quantity is the following:

(i) Speed (ii) Area (iii) Force (iv) Distance

Ans: **i.** Distance can be considered as base quantity, because distance is equal to length and its unit is metre.

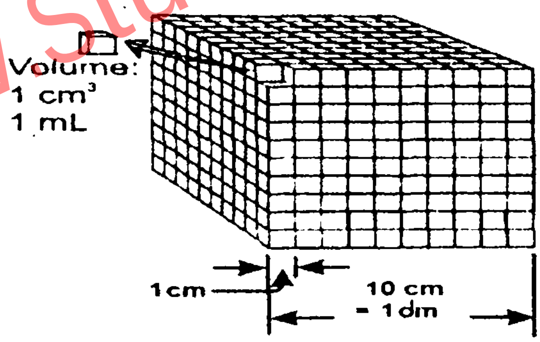
ii. Speed, area and force are derived quantities because these quantities are express in terms of base quantities.

3. Identify the following as base or derived quantity:
density, force, mass, speed, time, length, temperature and volume.

Ans:

Base Quantities	Derived Quantities
Mass, time, length, temperature.	Density, force, speed, volume.

Mini Exercise



Volume is a derived quantity

$$1\ L = 1000 mL$$
$$1\ L = 1\ dm^3$$
$$= (10\ cm)^3$$
$$= 1000\ cm^3$$
$$\therefore\ 1\ mL = 1\ cm^3$$

Express 1 m^3 in litres L

Solution: 1 m^3 in litres = 1000 L

Q14. Define prefixes. Interconvert the prefixes and their symbols to indicate multiples and sub-multiples for both base and derived units?

Ans: Prefixes:

Prefixes are the words or letters added before SI units such as kilo, mega, giga and milli.

SI units have the advantage that their multiples and sub-multiples can be expressed in terms of prefixes.

These prefixes are given in Table.

Some Prefixes

Prefix	Symbol	Multiplier
exa	E	10^{18}
peta	P	10^{15}
tera	T	10^{12}
giga	G	10^{9}
mega	M	10^{6}
kilo	k	10^{3}
hecto	h	10^{2}
deca	da	10^{1}
deci	d	10^{-1}
centi	c	10^{-2}
milli	m	10^{-3}
micro	M	10^{-6}
nano	n	10^{-9}
pico	P	10^{-12}
femto	f	10^{-15}
atto	a	10^{-18}

Advantages of prefixes:

The prefixes are useful to express very large or small quantities. For example, divide 20,000 g by 1000 to express it into kilogram, since kilo represents 10^3 or 1000.

Thus $20{,}000\,g = \frac{20{,}000}{1000}\,Kg = 20\,kg$

or $20{,}000\,g = 20 \times 10\,g = 20\,kg$

Note:

Double prefixes are not used. For example, no prefix is used with kilogramme since it already contains the prefix kilo.

Prefixes given in Table are used with both types base and derived units.

Multiples and sub-multiples of length:

1 km	10^{3}m
1 cm	10^{-2}m
1 mm	10^{-3}m
1 μm	10^{-6}m
1 nm	10^{-9}m

Q15. What do you understand by scientific notation?

Ans: Scientific notation/Standard form:

In scientific notation a number is expressed as some power of ten multiplied by a number between 1 and 10.

Examples:

i. The Moon is 384000000 metres away from the Earth. Distance of the moon from the Earth can also be expressed as $3.84 \times 10^8\ m$. This saves writing down or interpreting large numbers of zeros.

ii. A number 62750 can be expressed as 6.275×10^4. Similarly the standard form of 0.00045 s is 4.5×10^{-4}s.

Quick Quiz

1. Name five prefixes most commonly used.

Ans: **(1)** kilo (k) = 10^3 **(2)** centi (c) 10^{-2} **(3)** milli (m) = 10^{-3}
(4) micro (μ) = 10^{-6} **(5)** mega (M) = 10^6

2. The Sun is one hundred and fifty million kilometres away from the Earth. Write this.
(a) as an ordinary whole number. **(b) in scientific notation.**

Ans: The distance of Sun from the Earth = 150 million km

(a) as an ordinary whole number:

$= 150 \times 10^6 \text{ km} = 150 \times 10^6 \times 10^3 \text{ m}$ ($\because$ 1 million 10^6, 1 kilo = 10^3)

150000000000 m

(b) in scientific notation.

$= 150 \times 10^6 \times 10^3$
$= 150 \times 10^9$
$= 15 \times 10 \times 10^9$
$= 15 \times 10^{10}$
$= \frac{15}{10} \times 10 \times 10^{10}$
$= 1.5 \times 10^{11}$
$= 1.5 \times 10^{11}$ m

3. Write the numbers given below in scientific notation.
(a) 3000000000 ms^{-1} **(b) 6400000 m**
(c) 0.0000000016 g **(d) 0.0000548 s**

Ans: **(a) 3000000000 ms^{-1}**

$= 3 \times 1000000000\ ms^{-1}$
$= 3 \times 10^9\ ms^{-1}$

(b) 6400000 m

$= 64 \times 10^5$ m
$= 6.4 \times 10 \times 10^5$
$= 6.4 \times 10^6$ m

(c) 0.0000000016 g

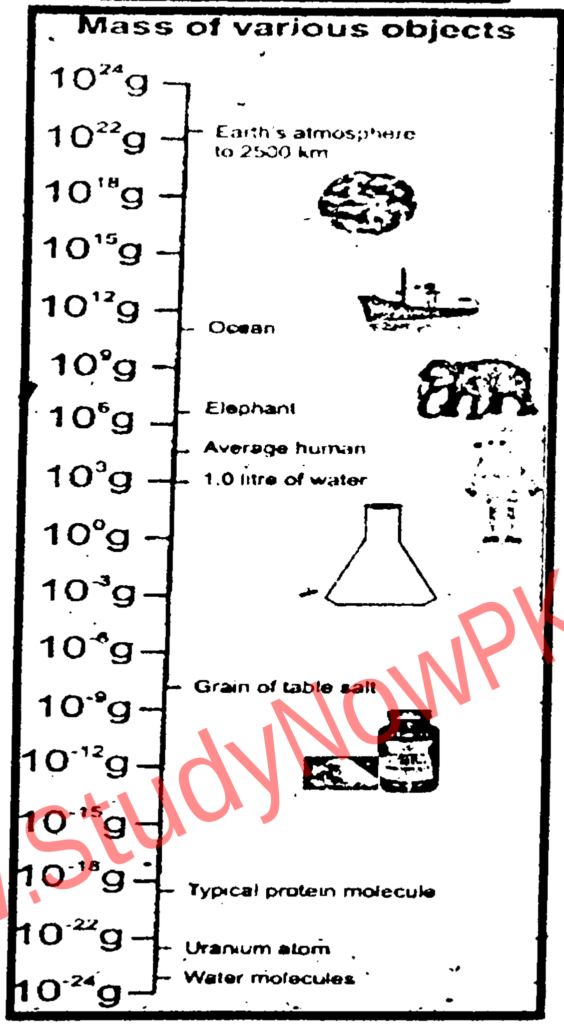
$= \frac{0.0000000016}{10000000000}$ g
$= 16 \times 10^{-10}$ g
$= 1.6 \times 10 \times 10^{-10}$ g
$= 1.6 \times 10^{-9}$ g

(d) 0.0000548 s

0.0000548
$= \frac{0.0000548}{10000000}$
$= 548 \times 10^{-7}$

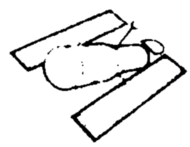
$= 5.48 \times 10^{2} \times 10^{-7}$
$= 5.48 \times 10^{-5}$ s

Tidbits



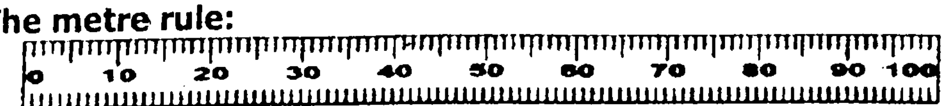
FOR YOUR INFORMATION

Hubble Space Telescope:
Hubble Space Telescope orbits around the Earth.
It provides information about stars.



Q16. What is a metre rule? What is the least count of a metre rule used in the laboratories?

Ans: The metre rule:



A metre rule is a length measuring instrument as shown in figure. It is commonly used in the laboratories to measure length of an object or distance between two points. It is one meter long which is equal to 100 centimeters. Each centimeter (cm) is divided into 10 small divisions called millimeter (mm). Thus one

millimeter is the smallest reading that can be taken using a meter rule and is called its least count.

Least count of metre rule = 0.1 cm or 1 mm

Q17. What is a measuring tape? What is the least count of a measuring tape?

Ans: The measuring tape:

Measuring tapes are used to measure length in meters and centimeters. A measuring tape used by blacksmith and carpenters. A measuring tape consists of a thin and long strip of cotton, metal or plastic generally 10 m, 20 m, 50 m or 100 m long. Measuring tapes are marked in centimeters as well as in inches.

Least count of measuring tape = 0.1 cm or 1 mm

Mini Exercise

Cut a strip of paper sheet. Fold it along its length. Now mark centimetres and half centimetre along its length using a ruler. Answer the following questions:

1. What is the range of your paper scale?

Ans: The range of paper scale is 20 cm.

2. What is its least count?

Ans: The least count of paper scale is 1 cm.

3. Measure the length of a pencil using your paper scale and with a metre ruler. Which one is more accurate and why?

Ans: The measurement of pencil measured by the metre ruler is 4.2 cm.
The measurement of pencil measured by the ruler is more accurate because it even can measure the length in millimetres,

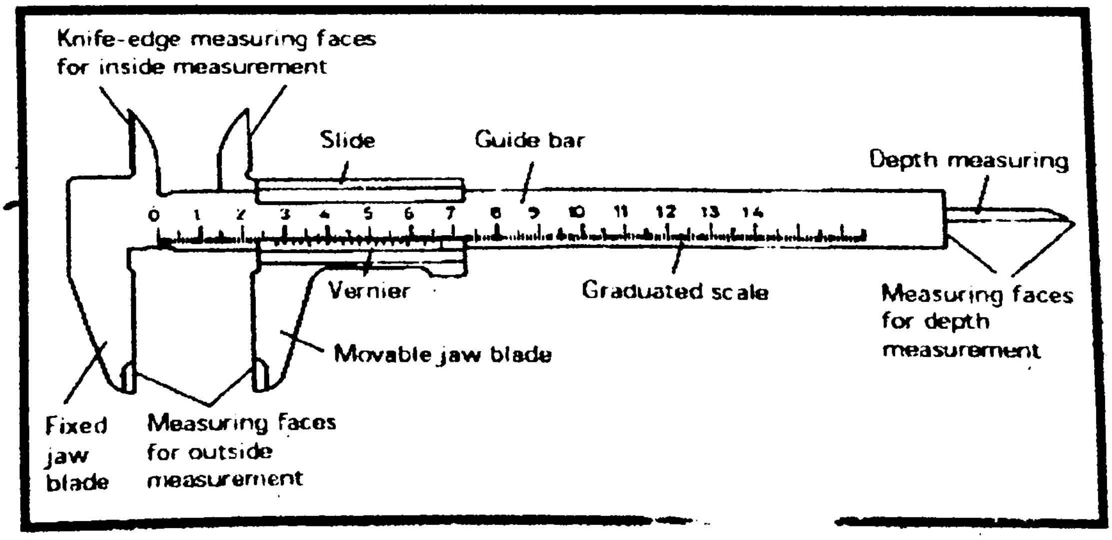
Q18. Describe the construction and working of vernier callipers?

Ans: Vernier callipers:

An instrument used to measure small lengths such as internal or external diameter or length of a cylinder, etc is called as Vernier Callipers.

Construction:

A Vernier Callipers consists of two jaws. One is a fixed jaw with main scale attached to it.



Main scale:

Main scale has centimeter and millimeter marks on it. The other jaw **is a** moveable jaw.

vernier scale:

It has vernier scale having 10 divisions over it such that each of its division is 0.9 mm.

Least count (LC)/Vernier constant:

The difference between one small division on main scale division and one vernier scale division is 0.1 mm. It is called least count (LC) of the Vernier Callipers. Least count of the Vernier Callipers can also be found as given below:

$$Least\ count\ of\ Vernier\ Callipers = \frac{smallest\ reading\ on\ main\ scale}{number\ of\ divisions\ on\ vernier\ scale}$$

$$= \frac{1\ mm}{10\ division} = 0.1\ mm$$

Hence $$L\,C = 0.1\ mm = 0.01\ cm$$

Working of a Vernier Callipers:

First of all find the error, if any, in the measuring instrument. It is called the zero error of the instrument. Knowing the zero error, necessary correction can be made to find the correct measurement. Such a correction is called zero correction of the instrument. Zero correction is the negative of zero error.

Taking a Reading on Vernier Callipers:

Let us find the diameter of a solid cylinder using Vernier Callipers. Place the solid cylinder between jaws of the Vernier Callipers. Close the jaws till they press the opposite sides of the object gently.

Note the complete divisions of main scale past the vernier scale zero in a tabular form. Next find the vernier scale division that is coinciding with any division on the main scale. Multiply it by least count of Vernier Callipers and add it in the main scale reading. This is equal to the diameter of the solid cylinder. Add zero correction (Z.C) to get correct measurement. Repeat the above procedure and record at least three observations with the solid cylinder displaced or rotated each time.

Q19. What is zero error? How zero error is corrected?

OR

What do you understand by the zero error of a measuring instrument? Why is the use of zero error necessary in a measuring instrument?

Ans: Zero Error and Zero Correction:

To find the zero error, close the jaws of Vernier Callipers gently. If zero line of the vernier scale coincides with the zero of the main scale then the zero error is **zero**. Zero error will exist if zero line of the vernier scale is not coinciding with the zero of main scale.

Positive zero error:

Zero error will be positive if zero line of vernier scale is on the right side of the zero of the main scale.

To get the correct value zero error must be recorded and subtracted from each reading.

Negative zero error:

Zero error will be negative if zero line of vernier scale is on the left side of zero of the main scale.

To get the correct value zero error must be recorded and add to each reading.

Quick Quiz

1. What is the least count of the Vernier Callipers?

Ans: The least count of the Vernier Calliper is 0.1 mm or 0.01 cm.

2. What is the range of the Vernier Callipers used in your Physics laboratory?

Ans: Range of the Vernier Callipers used in your Physics laboratory is 12 cm.

3. How many divisions are there on its vernier scale?

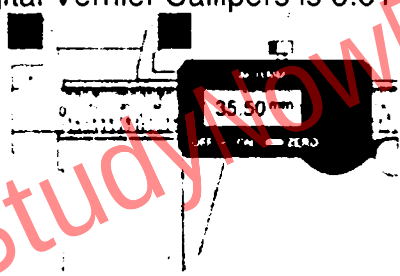
Ans: Vernier scale has 10 divisions over it such that each of its division is 0.9 mm.

4. Why do we use zero correction?

Ans: Zero correction is used to get correct and exact measurement.

DIGITAL VERNIER CALLIPERS

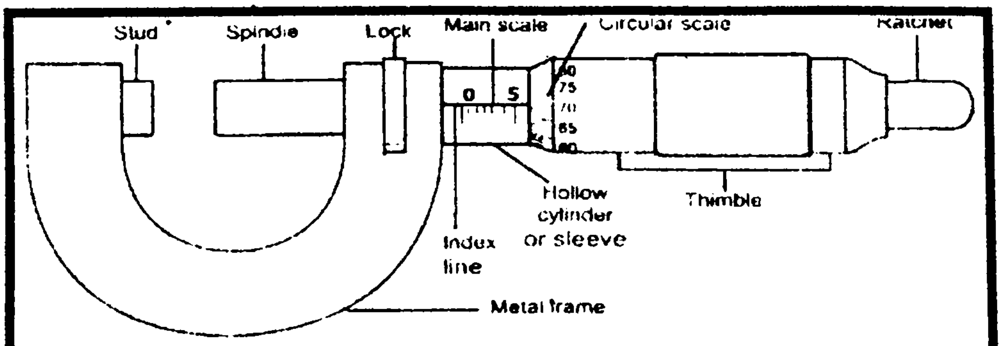
Digital Vernier Callipers has greater precision than mechanical Vernier Callipers. Least count of Digital Vernier Callipers is 0.01 mm.



Q20. Describe the construction and working of screw gauge?

Ans: Screw gauge:

A screw gauge is an instrument that is used to measure small lengths with accuracy greater than a Vernier Calliper. It is also called as micrometer screw gauge.



A micrometer screw gauge

Construction:

A simple screw gauge consists of a U-shaped metal frame with a metal stud at its one end. A hollow cylinder (or sleeve) has a millimetre scale over it along a line called index line parallel to its axis. The hollow cylinder acts as a nut. It is fixed

at the end of U-shaped frame opposite to the stud. A Thimble has a threaded spindle inside it. As the thimble completes one rotation, the spindle moves 1 mm along the index line. It is because the distance between consecutive threads on the spindle is 1 mm. This distance is called the pitch of screw on the spindle.

Least count of screw gauge:

$$Least\ count \ = \frac{pitch\ of\ the\ screw\ gauge}{no.of\ division\ on\ circular\ scale}$$

$$= \frac{1\ mm}{100} = 0.01\ mm = 0.001\ cm$$

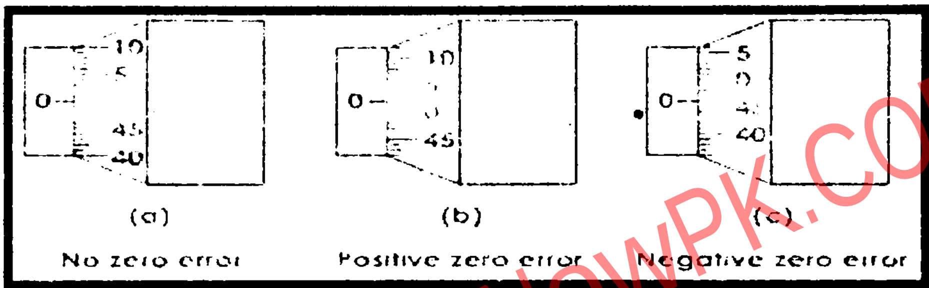
Thus least count of the screw gauge is 0.01 mm or 0.001 cm.

Working of a screw gauge:

The first step is to find the zero error of the screw gauge.

Zero error:

To find the zero error, close the gap between the spindle and the stud of the screw gauge by rotating the ratchet in the clockwise direction. If zero of circular scale coincides with the index line, then the zero error will be zero.



(a) No zero error (b) Positive zero error (c) Negative zero error

Positive zero error:

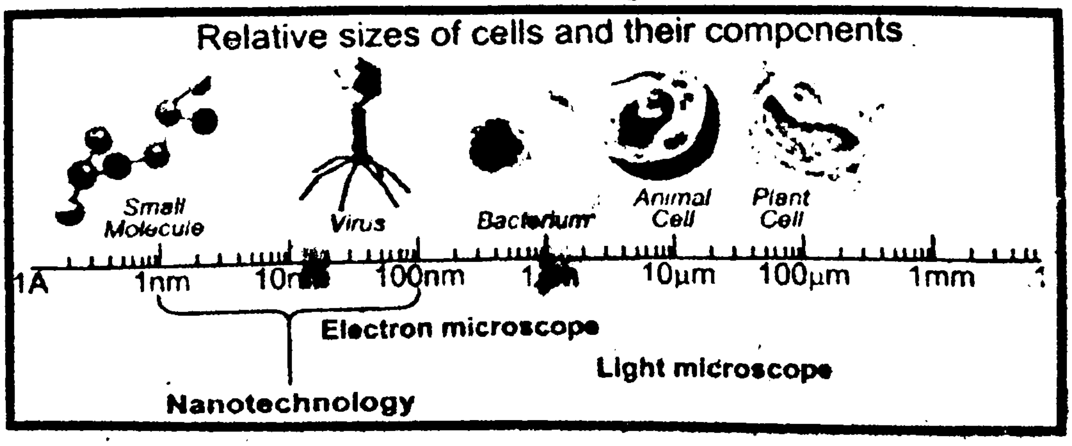
Zero error will be positive if zero of circular scale is behind the index line. In this case. multiply the number of divisions of the circular scale that has not crossed the index line with the least count of screw gauge to find zero error.

Negative zero error:

Zero error will be negative if zero of circular scale has crossed the index line. In this case, multiply the number of divisions of the circular scale that has crossed the index line with the least count of screw gauge to find the negative zero error.

Tidbits

Relative sizes of molecules and micro-organisms.



Mini Exercise

1. What is the least count of a screw gauge?

Ans: The least count of the screw gauge is 0.01 mm or 0.001 cm.

2. What is the pitch of your laboratory screw gauge?

Ans: The pitch of our laboratory screw gauge is 1mm.

3. What is the range of your laboratory screw gauge?

a) Vernier Callipers **b) Screw Gauge**

Ans: The range of our laboratory screw gauge is 100 mm.

4. Which one of the two instruments is more precise and why?

a) Vernier Callipers **b) Screw Gauge**

Ans: The least count of vernier callipers is 0.01cm while the least count of screw gauge is 0.001 cm.

The vernier callipers measure the length with an accuracy of 0.01 cm. The screw gauge measure the length with an accuracy of 0.001 cm. therefore screw gauge is more precise instrument.

USEFUL INFORMATION

Least count of ruler is 1mm. It is 0.1mm for Vernier Callipers and 0.01mm for micrometer screw gauge. Thus measurements taken by micrometer screw gauge are the most precise than the other two.

Q21. Describe the construction and working of beam balance?

Ans: Beam balance:

Pots were used to measure grain in various part of the world in the ancient times. However, balances were also in use by Greeks and Romans. Beam balances are still in use at many places. In a beam balance, the unknown mass is placed in one pan. It is balanced by putting known masses in the other pan. Today people use many types of mechanical and electronic balances.

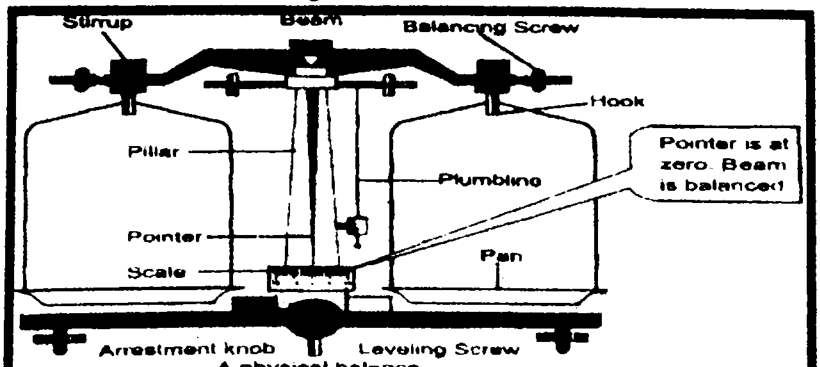
Q22. Describe the construction and working of physical balance?

Ans: Physical balance:

A physical balance is used in the laboratory to measure the mass of various objects by comparison.

Construction and working:

It consists of a beam resting at the centre on a fulcrum.



A physical balance

The beam carries scale pans over the hooks on either side. Unknown mass is placed on the left pan. Find some suitable standard masses that cause the pointer to remain at zero on raising the beam.

Mini Exercise

1. What is the function of balancing screws in a physical balance?

Ans: We use the balancing screws to remove the zero error of the physical balance.

Balancing screws in a physical balance is used to bring the pointer at zero position.

OR (Second answer)

There are two screws on the physical balance. One is on the left side and other is on the right side of the physical balance. If pointer is not in middle of the scale, we move these screws forwards or backwards to bring the pointer in the middle of the scale. This is done before we put any mass or weight in either of the pan.

In other words we use the screws to remove the zero error of the physical balance.

2. On what pan we place the object and why?

Ans: We Place the object into left pan. In case of physical balance, there the body is fixed and the weights have to be added in denominations. So only for convenience we put the weights on the right pan after keeping body on the left pan. If suppose a left handed person weighs in a physical balance then no harm in placing the body in the right pan and putting the denominations of the weights on the left pan.

Q23. Describe the construction and working of lever balance?

Ans: Lever balance:

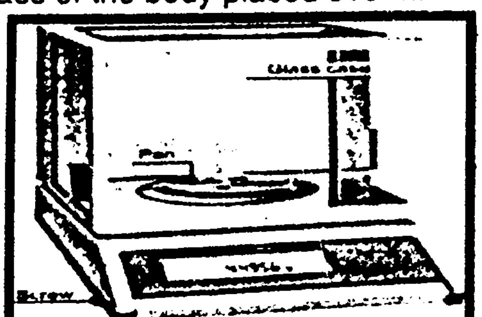
A lever balance consists of a system of levers. When lever is lifted placing the object in one pan and standard masses on the other pan, the pointer of the lever system moves. The pointer is brought to zero by varying standard masses.

A lever balance

Q24. Describe the construction and working of electronic balance?

Ans: Electronic balance:

Electronic balances come in various ranges; milligram ranges, gram ranges and kilogram ranges. Before measuring the mass of a body, it is ***switched ON*** and its reading is ***set to zero***. Next place the object to be weighed. The reading on the balance gives you the mass of the body placed over it.



An electronic balance

Q25. Which type of balance is more precise to measure the mass of an object?

Ans: The most Accurate Balance:

The mass of one rupee coin is done using different balances as given below:

(a) Beam Balance:

Let the balance measures coin's mass $= 3.2\ g$

A sensitive beam balance may be able to detect a change as small as of $0.1\ g$ or $100\ mg$.

(b) Physical Balance:

Let the balance measures coin's mass $= 3.24\ g$

Least count of the physical balance may be as small as $0.01\ g$ or $10\ mg$. Therefore, its measurement would be more precise than a sensitive beam balance.

(c) Electronic Balance:

Let the balance measures coin's mass $= 3.247\ g$

Least count of an electronic balance is $0.001\ g$ or $1\ mg$. Therefore, its measurement would be more precise than a sensitive physical balance.

Conclusion:

Thus electronic balance is the most sensitive balance in the above balances.

USEFUL INFORMATION

The precision of a balance in measuring mass of an object is different for different balances. A sensitive balance cannot measure large masses. Similarly a balance that measures large masses cannot be sensitive.

Some digital balances measure even smaller difference of the order of 0.0001 g or 0.1 mg. Such balances are considered the most precise balance.

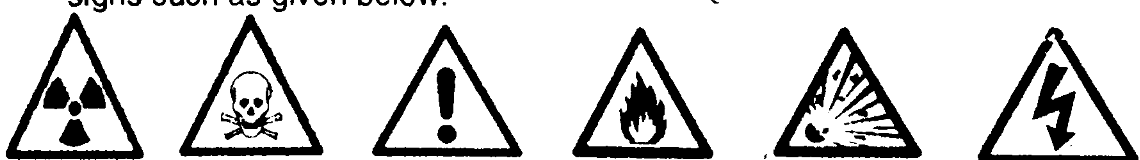
Q26. What is a stopwatch? What is the least count of a mechanical stopwatch you have used in the laboratories?

Ans: See Q # 1.10 from Exercise.

LABORATORY SAFETY EQUIPMENTS

A school laboratory must have safety equipments such as:

- Waste-disposal basket
- Fire extinguisher.
- Fire alarm.
- First Aid Box.
- Sand and water buckets.
- Fire blanket to put off fire.
- Substances and equipments that need extra care must bear proper warning signs such as given below:



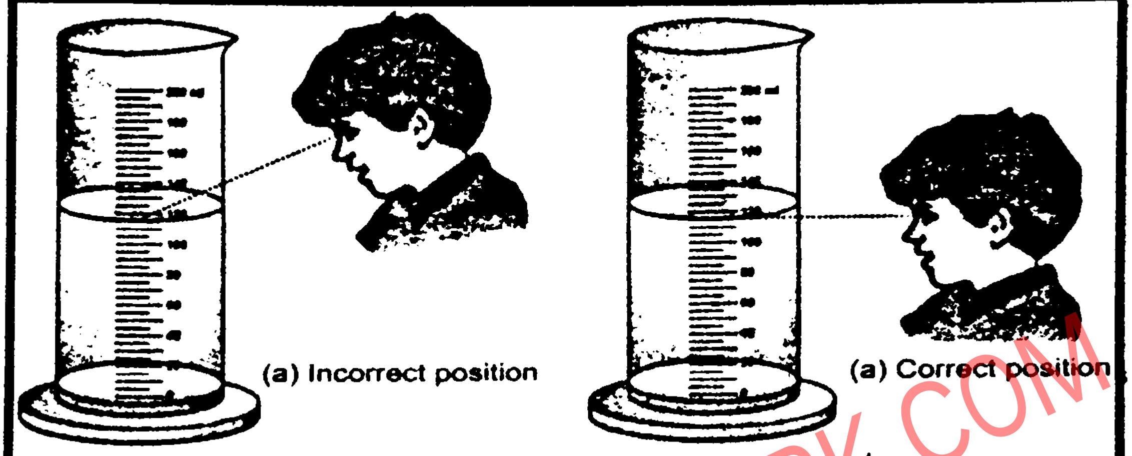
Radioactive Poison General danger Flammable Explosive Electric hazard

Q27. What is a measuring cylinder? Write the method to use the measuring cylinder?

Ans: Measuring cylinder:

A measuring cylinder is a graduated glass cylinder marked in millilitres. It is used to measure the volume of a liquid and also to find the volume of an irregular shaped solid object.

It has a scale along its length that indicates the volume in milliliter (mL). Measuring cylinders have different capacities from $100\ mL$ to $2500\ mL$.



(a) Wrong way to note the liquid level keeping eye above liquid level.
(b) correct position of eye to note the liquid level keeping eye at liquid level.

How to use a measuring cylinder:

While using a measuring cylinder, it must be kept vertical on a plane surface. Take a measuring cylinder. Place it vertically on the table. Pour some water into it. Note that the surface of water is curved. The meniscus of the most liquids curve downwards while the meniscus of mercury curves upwards.

Correct method to note the level of a liquid:

The correct method to note the level of a liquid in the cylinder is to keep the eye at the same level as the meniscus of the liquid. It is incorrect to note the liquid level keeping the eye above the level of liquid.

When the eye is above the liquid level, the meniscus appears higher on the scale. Similarly when the eye is below the liquid level, the meniscus appears lower than actual height of the liquid.

Q28. How can we measure the volume of small irregular shape objects which floats (piece of cork) on the water by using a measuring cylinder?

Ans: Measuring volume of an irregular shaped solid:

Measuring cylinder can be used to find the volume of a small irregular shaped solid that sinks in water. Let us find the volume of a small stone. Take some water in a graduated measuring cylinder. Note the volume V, of water in the cylinder. Tie the solid with a thread. Lower the solid into the cylinder till it is fully immersed in water. Note the volume V_f of water and the solid. Volume of the solid will be $V_f - V_i$.

LABORATORY SAFETY RULES

The students should know what to do in case of an accident. The charts or posters are to be displayed in the laboratory to handle situations arising from any mishap or accident. For your own safety and for the safety of others in the laboratory, follow safety rules given below:

1. Do not carry out any experiment without the permission of your teacher.
2. Do not eat, drink, play or run in the laboratory.
3. Read the instructions carefully to familiarize yourself with the possible hazards before handling equipments and materials.
4. Handle equipments and materials with care.
5. Do not hesitate to consult your teacher in case of any doubt.
6. Do not temper with the electrical appliances and other fittings in the laboratory.
7. Report any accident or injuries immediately to your teacher.

Q29. What is meant by the significant figures of a measurement? What are the main points to be kept in mind while determining the significant figures of a measurement?

Ans: See Q # 1.12 from Exercise.

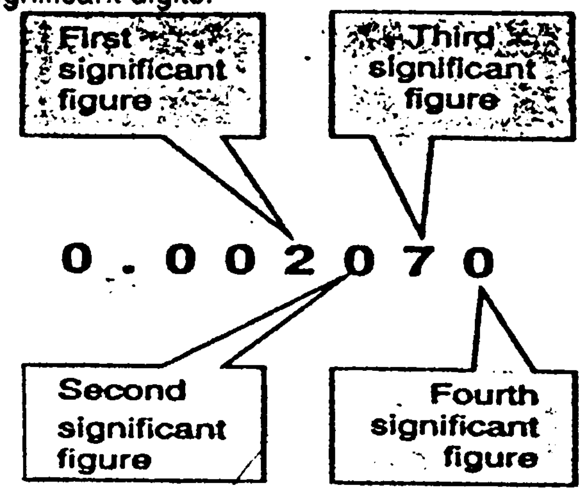
RULES TO FIND THE SIGNIFICANT DIGITS IN A MEASUREMENT

(i) Digits other than zero are always significant.
27 has 2 significant digits.
275 has 3 significant digits.

(ii) Zeros between significant digits are also significant.
2705 has 4 significant digits.

(iii) Final zero or zeros after decimal are significant
275.00 has 5 significant digits.

(iv) Zeros used for spacing the decimal point are not significant Here zeros are placeholders only.
0.03 has 1 significant digit.
0.027 has 2 significant digits.



ROUNDING THE NUMBERS

(i) If the last digit is less than 5 then it is simply dropped. This decreases the number of significant digits in the figure.

For example,

1.943 is rounded to 1.94 (3 significant figure)

(ii) If the last digit is greater than 5, then the digit on its left is increased by one. This also decreases the number of significant digits in the figure.

For example,

1.47 is rounded to two significant digits 1.5

(iii) If the last digit is 5, then it is rounded to get nearest even number.

For example,

1.35 is rounded to 1.4 and 1.45 is also rounded to 1.4

SUMMARY

1. **Physics:** Physics is a branch of Science that deals with matter, energy and their relationship.
2. **Branches of Physics:** Some main branches of Physics are mechanics, heat, sound, light (optics), electricity and magnetism, nuclear physics and quantum physics.
3. **Role of physics in daily life:** Physics plays an important role in our daily life. For example, electricity is widely used everywhere, domestic appliances, office equipments, machines used in industry, means of transport and communication etc. work on the basic laws and principles of Physics.
4. **Physical quantity:** A measurable quantity is called a physical quantity.
5. **Base quantities:** Base quantities are defined independently. Seven quantities are selected as base quantities. These are length, time, mass, electric current, temperature, intensity of light and the amount of a substance.
6. **Derived quantities:** The quantities which are expressed in terms of base quantities are called derived quantities. For example, speed, area, density, force, pressure, energy, etc.
7. **International system of units (SI):** A world-wide system of measurements is known as international system of units (SI). In SI, the units of seven base quantities are metre, kilogramme, second, ampere, kelvin, candela and mole.
8. **Prefixes:** The words or letters added before a unit and stand for the multiples or sub-multiples of that unit are known as prefixes. For example, kilo, mega, milli, micro, etc.
9. **Scientific notation or standard form:** A way to express a given number as a number between 1 and 10 multiplied by 10 having an appropriate power is called scientific notation or standard form.

10. **Vernier Callipers:** An instrument used to measure small lengths such as internal or external diameter or length of a cylinder, etc is called as Vernier Callipers.
11. **Screw gauge:** A Screw gauge is used to measure small lengths such as diameter of a wire, thickness of a metal sheet, etc.
12. **Physical balance:** Physical balance is a modified type of beam balance used to measure small masses by comparison with greater accuracy.
13. **Stopwatch:** A stopwatch is used to measure the time interval of an event. Mechanical stopwatches have least count upto 0.1 seconds. Digital stopwatch of least count 0.01s is common.
14. **Measuring cylinder:** A measuring cylinder is a graduated glass cylinder marked in millilitres. It is used to measure the volume of a liquid and also to find the volume of an irregular shaped solid object.
15. **Significant figures:** All the accurately known digits and the first doubtful digit in an expression are called significant figures. It reflects the precision of a measured value of a physical quantity.

QUESTIONS

1.1 Encircle the correct answer from the given choices.

i. The number of base units in are:

A. 3 B. 6
C. 7 D. 9

ii. Which one of the following unit is not a derived unit?

A. pascal B. kilogramm
C. newton D. watt

iii. Amount of a substance terms of numbers is measur in:

A. gram B. kilogramn
C. newton D. mole

iv. An interval of 200μs equivalent to

A. 0.2 s B. 0.02 s
C. 2×10^{-4} s D. 2×10^{-6} s

v. Which one of the following the smallest quantity?

A. 0.01 g B. 2 mg
C. 100 μg D. 5000 ng

vi. Which instrument is most suitable to measure the internal diameter of a test tube?

A. metre rule B. Vernier Callipers
C. measuring tap D. screw gauge

vii. A student claimed the diameter of a wire as 1.032 cm using Vernier Callipers up to what extent do you agree with it?

A. 1 cm B. 1.0 cm
C. 1.03 cm D. 1.032 cm

viii. A measuring cylinder is used to measure:

A. mass B. area

C. volume D. level of a liquid

ix. A student noted the thickness of a glass sheet using a screw gauge. On the main scale, it reads 3 divisions while 8th division on the circular scale coincides with index line. Its thickness is:

A. 3.8 cm B. 3.08 mm

C. 3.8 mm D. 3.08 m

x. Significant figures in an expression are:

A. all the digits

B. all the accurately known digits

C. all the accurately known digits and the first doubtful digit

D. all the accurately known and all the doubtful digits

Answers

i. C	**ii. B**	**iii. D**	**iv. C**	**v. D**
vi. B	**vii. C**	**viii. C**	**ix. B**	**x. C**

1.2 What is the difference between base quantities and derived quantities? Give three examples in each case.

Ans: Difference between base quantities and derived quantities:

Base quantities:

Base quantities are the quantities on the basis of which other quantities are expressed.

There are seven physical quantities which form the foundation for other physical quantities. These physical quantities are called the base quantities.

Examples:

Length, mass, time, electric current, temperature, intensity of light and the amount of a substance.

Derived quantities:

The quantities that are expressed in terms of base quantities are called derived quantities.

Examples:

Area, volume, speed, force, work, energy, power, electric charge, electric potential, etc.

1.3 Pick out the base units in the following:
joule, newton, kilogramme, hertz, mole, ampere, metre, kelvin, coulomb and watt.

Ans: Base units:

kilogramme, mole, ampere, metre, Kelvin.

1.4 Find the base quantities involved in each of the following derived quantities:

(a) speed (b) volume (c) force (d) work

Ans: (a) speed:

$$\text{Speed} = \frac{\text{distance covered}}{\text{time taken}}$$

$$\text{Unit of speed} = \frac{\text{metre}}{\text{second}} = \text{ms}^{-1}$$

Base quantities involved in speed are metre and second.

(b) Volume:

Volume = length × width × height

Volume = m × m × m = m^3

Base quantity involved in volume is metre.

(c) Force:

$$F = ma$$

$$1N = 1\,kg \times 1\,ms^{-2}$$

or

$$1N = 1\,kgms^{-2}$$

Base quantities involved in force are kilogramme, metre and second.

(d) Work:

$$\text{Work done} = \text{Force} \times \text{displacement}$$

$$W = FS \quad \ldots\ldots\ldots\ldots (i)$$

$$1\,J = 1\,N \times 1\,m$$

$$1\,J = 1\,kgms^{-2} \times 1\,m$$

$$1\,J = 1\,kgm^2s^{-2}$$

Base quantities involved in work are kilogramme, metre and second.

1.5 Estimate your age in seconds.

Ans: Suppose my age = 15 years

= 15 × 365 = 5475 days ($\because$ 1 year = 365 days)

= 5475 × 24 = 131400 hours ($\because$ 1 day = 24 Hours)

= 131400 × 60 = 7884000 minutes ($\because$ 1 hour = 60 Minutes)

= 7884000 × 60 = 473040000 seconds ($\because$ 1 minute = 60 second)

1.6 What role SI units have played in the development of science?

Ans: **i.** SI system is in use all over the world.

ii. Manipulation in this system is quite easy i.e. the multiple and sub multiple of different units are obtain simply by multiplying or dividing with ten or powers of tens.

1.7 What is meant by vernier constant?

Ans: **Least count (LC)/Vernier constant:**

The difference between one small division on main scale division and one vernier scale division is 0.1 mm. It is called least count (LC) of the Vernier Callipers. Least count of the Vernier Callipers can also be found as given below:

$$\textit{Least count of Vernier Callipers} = \frac{\textit{smallest reading on main scale}}{\textit{number of divisions on vernier scale}}$$

$$= \frac{1\,mm}{10\,division} = 0.1\,mm$$

Hence $LC = 0.1\,mm = 0.01\,cm$

1.8 What do you understand by the zero error of a measuring instrument?

Ans: **Zero Error and Zero Correction:**

It is a defect in a measuring device (Vernier Callipers & Screw Gauge) & zero error is caused by an incorrect position of the zero point.

For Example:

To find the zero error, close the jaws of Vernier Callipers gently. If zero line of the vernier scale coincides with the zero of the main scale then the zero error is **zero**. Zero error will exist if zero line of the vernier scale is not coinciding with the zero of main scale.

1.9 Why is the use of zero error necessary in a measuring instrument?

Ans: When making some kind of scientific measurement, it is necessary to first check your measuring instrument for 'zero error'. The zero error is the reading displayed when you *know* the true reading should be exactly zero.

For example, using a set of vernier calipers, the zero error is the reading that shows when the calipers are fully closed.

As long as you check for zero error, you can then use it to correct your readings.

Positive zero error:

Zero error will be positive if zero line of vernier scale is on the right side of the zero of the main scale.

To get the correct value zero error must be recorded and subtracted from each reading.

Negative zero error:

Zero error will be negative if zero line of vernier scale is on the left side of zero of the main scale.

To get the correct value zero error must be recorded and add to each reading.

1.10 What is a stopwatch? What is the least count of a mechanical stopwatch you have used in the laboratories?

Ans: Stopwatch:

A stopwatch is used to measure the time interval of an event.

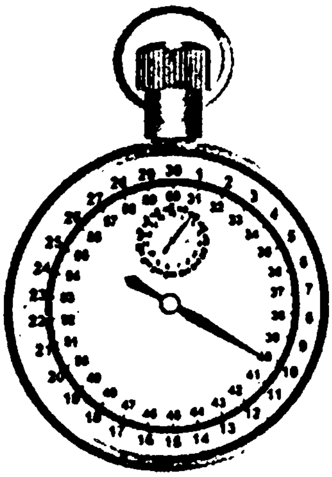
Types of stopwatch:

There are two types of stopwatches; mechanical and digital.

Mechanical stopwatch:

A mechanical stopwatch can measure a time interval up to a minimum 0.1 second.

Least count of mechanical stop watch is 0.1 second.



A mechanical stopwatch

Digital stopwatches:

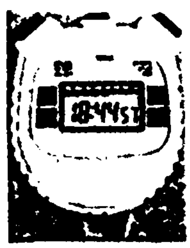
Digital stopwatches commonly used in laboratories can measure a time interval as small as 1/100 second or 0.01 second.

Least count of digital stop watch is 0.01 second.

How to use a Stopwatch:

Use of a mechanical stopwatch:

A mechanical stopwatch has a knob that is used to wind the spring that powers the watch. It can also be used as a start-stop and reset button. The watch starts when the knob is pressed once. When pressed second time, it stops the watch while the third press brings the needle back to zero position.



A digital stopwatch

Use of a digital stopwatch:

The digital stopwatch starts to indicate the time lapsed as the start/stop button is pressed. As soon as start/stop button is pressed again, it stops and indicates the time interval recorded by it between start and stop of an event. A reset button restores its initial zero setting.

1.11 Why do we need to measure extremely small interval of times?

Ans: We need extremely small interval of time "delta t" (Δt) as the smaller is the time interval better resolution of measurement is possible.

For Example:

In atomic/quantum physics especially reactions take place in a very short amount of time.

1.12 What is meant by significant figures of a measurement?

Ans: Significant figures:

All the accurately known digits and the first doubtful digit in an expression are called significant figures. It reflects the precision of a measured value of a physical quantity.

The accuracy in measuring a physical quantity depends upon various factors:

i. The quality of the measuring instrument

ii. The skill of the observer

iii. The number of observations made

For example, a student measures the length of a book as 18 *cm* using a measuring tape. The numbers of significant figures in his/her measured value are two. The left digit 1 is the accurately known digit. While the digit 8 is the doubtful digit for which the student may not be sure.

Rules for determining significant figures:

The following rules are helpful in identifying significant figure:

(i) Non-zero digits are always significant.

(ii) Zeros between two significant figures are also significant.

(iii) Final or ending zeros on the right in decimal fraction are significant.

(iv) Zeros written on the left side of the decimal point for the purpose of spacing the decimal point are not significant.

(v) In whole numbers that end in one or more zeros without a decimal point. These zeros may or may not be significant. In such cases, it is not clear which zeros serve to locate the position value and which are actually parts of the measurement. In such a case, express the quantity using scientific notation to find the significant zero.

1.13 How is precision related to the significant figures in a measured quantity?

Ans: The greater the number of significant figures, the greater the precision. Each significant figures increases the precision by a factor of ten.

An improvement in the quality of measurement by using better instrument increases the significant figures in the measured result. The significant figures are all the digits that are known accurately and the one estimated digit. More significant figure means greater precision.

PROBLEMS

1.1 Express the following quantities using prefixes.

(a) 5000 g **(b) 2000000 W**

(c) 52×10^{-10} kg **(d) 225×10^{-8} s**

{(a) 5 kg (b) 2 MW (c) 5.2 μg (d) 2.25 μs }

Solution:

(a) 5000 g

$= 5 \times 1000$g

$= 5 \times 1$kg (Since 1000 g = 1 kg)

$= 5$ kg

(b) 2000,000 W

$= 2 \times 1000000$

$= 2 \times 10^6$ W

$= 2 \times$ Mega W ($\because 10^6 = 1$Mega)

$= 2$ MW

(c) 52×10^{-10} kg

$= 5.2 \times 10 \times 10^{-10}$ kg

$= 5.2 \times 10^{-9}$ kg

$= 5.2 \times 10^{-9} \times 1000$ g (Since 1 kg = 1000 g)

$= 5.2 \times 10^{-9} \times 10^3$ g

$= 5.2 \times 10^{-6}$ g

$= 5.2\ \mu$g [$\because 10^{-6} = 1$micro(μ)]

(d) 225×10^{-8} s

$= 2.25 \times 10^2 \times 10^{-8}$ s

$= 2.25 \times 10^{-6}$ s

$= 2.25\ \mu$s [$\because 10^{-6} = 1$micro(μ)]

1.2 How do the prefixes micro, nano and pico relate to each other?

Solution:

As we know

micro = $\mu = 10^{-6}$

nano = n = 10^{-9}

pico = p = 10^{-12}

The relation between micro, nano and pico can be written as.

micro = 10^{-6}

nano = $10^{-6} \times 10^{-3} = 10^{-3}$ micro

pico = $10^{-6} \times 10^{-6} = 10^{-6}$ micro

1.3 Your hair grow at the rate of 1 mm per day. Find their growth rate in nm s^{-1}. (11.57 nm s^{-1})

Solution:

Growth rate of hair in nms^{-1} = 1mm per day

Growth rate of hair in one day = $24 \times 60 \times 60$ s

(Since 1 mm = 10^{-3} m and one day = $24 \times 60 \times 60$ s), hence

1 mm per day = 1×10^{-3} m $\times \frac{1}{24 \times 60 \times 60\ s}$

$= 1 \times 10^{-3}\ \text{m} \times \frac{1}{8400}\ ms^{-1}$
$= 1 \times 10^{-3}\ \text{m} \times 0.00001157$
$= 1 \times 10^{-3}\ \text{m} \times 1157 \times 10^{-8}\ ms^{-1}$
$= 1157 \times 10^{-2}\ \text{m} \times 10^{-9} ms^{-1}$
$= 11.57 \times 10^{-9}\ \text{ms}^{-1}$
1 mm per day $= 11.57\ \text{nms}^{-1}$
(because $10^{-9}\ \text{ms}^{-1} = 1\text{nms}^{-1}$),

1.4 Rewrite the following in standard form. (Scientific notation)
(a) 1168×10^{-27} (b) 32×10^{5} (c) 725×10^{-5} kg
(d) 0.02×10^{-8}
{**(a) 1.168×10^{-24} (b) 3.2×10^{6} (c) 7.25 g (d) 2×10^{-10}**}

Solution: (a) $1168 \times 10^{-27} = 1.168 \times 10^{3} \times 10^{-27} = 1.168 \times 10^{-24}$
(b) $32 \times 10^{5} = 3.2 \times 10^{1} \times 10^{5} = 3.2 \times 10^{6}$
(c) 725×10^{-5} kg $= 7.25 \times 10^{2} \times 10^{-5}$ kg $= 7.25 \times 10^{-3}$ kg
As (10^{-3} kg = 1g), therefore
7.25×10^{-3} kg = 7.25 g
(d) $0.02 \times 10^{-8} = 2 \times 10^{-2} \times 10^{-8} = 2 \times 10^{-10}$

1.5 Write the following quantities in standard form.
(a) 6400 km (b) 38000 km
(c) 300000000 ms^{-1} (d) seconds in a day
{**(a) 6.4×10^{3} km (b) 3.8×10^{5} km (c) $3 \times 10^{8}\ \text{m s}^{-1}$ (d) 8.64×10^{4} s**}

Solution: (a) 64000 km
Multiplying and dividing by "10^{3}"
$= \frac{6400\ \text{m}}{1000} \times 10^{3}\text{km}$
$= \frac{64\ \text{m}}{10} \times 10^{3}\text{km}$
$= 6.4 \times 10^{3}\text{km}$

(b) 38000 km
Multiplying and dividing by "10^{5}"
$= \frac{38000}{10^{5}} \times 10^{5}\text{km}$
$= \frac{380000}{10^{5}0000} \times 10^{5}\text{km}$
$= 3.8 \times 10^{5}\text{km}$

(c) 300000000 ms^{-1}
Multiplying and dividing by "10^{8}"
$= \frac{300000000\ \text{ms}^{-1}}{100000000} \times 10^{8}\text{km}$
$= 3 \times 10^{8}\text{km}$

(d) seconds in a day
As we know
1 day = 24 hours
1 hour = 60 minutes
1 minute = 60 seconds So
1 day = 24 × 60 × 60 seconds
1 day = 86400 s

1 day = 86400 s
Multiplying and dividing by 10^4

$= \frac{86400}{10000} \times 10^4$ s

$= 8.64 \times 10^4$ s

1.6 On closing the jaws of a Vernier Callipers, zero of the vernier scale is on the right to its main scale such that 4th division of its vernier scale coincides with one of the main scale division. Find its zero error and zero correction. (+0.04 cm, -0.04 cm)

Solution:

Main scale reading = 0.0 cm.
Vernier division coinciding with main scale = 4th division
Vernier scale reading = 4×0.01 cm = 0.04 cm
Zero error = 0.0 cm + 0.04 cm = 0.04 cm
Zero correction (Z.C) = -0.04 cm

The zero error of the vernier scale is 0.04cm and its zero correction is -0.04cm

$\left(\begin{matrix} \textit{vernier divison coinciding} \\ \textit{with main scale} \end{matrix}\right) = 4$ div

Vernier scale reading = 4×0.01 cm
= 0.04 cm

Scince zero of the vernier scale is on the right side of the zero of the main scale,thus the instrument has measured more than the actual reading. It is said to be positive zero error.

Zero correction is the negative of zero error. Thus
Zero error = +0.04 cm
and Zero correction = - 0.04 cm

1.7 A screw gauge has 50 divisions on its circular scale. The pitch of the screw gauge is 0.5 mm. What is its least count? (0.001 cm)

Solution:

Number of division on the circular scale = 50
Pitch of screw gauge = 0.5 mm
Least count of screw gauge L.C. = ?

$$\text{Least count} = \frac{Pitch}{Number\ of\ divisions\ on\ circular\ scale}$$

$$\text{Least count} = \frac{0.5\ mm}{50}$$

$$= 0.01\ \text{mm} = 0.01 \times \frac{1}{10}\ \text{cm}$$

Least count = 0.001 cm

1.8 Which of the following quantities have three significant figures?

(a) 3.0066 m **(b) 0.00309 kg**
(c) 5.05×10^{-27} kg **(d) 301.0 s**
{(b) and (c)}

Solution:

(a) 3.0066m

Zeros between significant digits are significant. Therefore, there are 5 significant figures in 3.0066 m.

(b) 0.00309kg

Zeros used for spacing the decimal point are not significant. Therefore, there are 3 significant figures in 0.00309kg.

(c) 5.05×10^{-27}kg

Only the digits before the exponent are considered, thus there are 3 significant figures.

(d) 301.0s

Final zeros or zeros after the decimal are significant. Therefore, there are 4 significant figures.

Result:

Quantities (b) and (c) have three significant figures.

1.9 What are the significant figures in the following measurements?

(a) 1.009 m **(b) 0.00450 kg**

(c) 1.66×10^{-27} kg **(d) 2001 s**

{(a) 4 (b) 3 (c) 3 (d) 4}

Solution:

(a) 1.009m

Since zeros between two significant figures are significant, so there are 4 significant figures.

(b) 0.00450

Zeros used for spacing the decimal point are not significant. Hence, there are 3 significant figures.

(c) 1.66×10^{-27}

Only the digits before the exponent are considered, so there are 3 significant figures.

(d) 2001s

Since zeros between two significant figures are significant, so there are 4 significant figures.

1.10 A chocolate wrapper is 6.7 cm long and 5.4 cm wide. Calculate its area up to reasonable number of significant figures. ($36\ cm^2$)

Solution:

Length of chocolate wrapper l = 6.7 cm

Width of chocolate wrapper w = 5.4 cm

Area = A = ?

$$\text{Area} = \text{Length} \times \text{Width}$$

$$A = l \times w$$

$$A = 6.7\text{cm} \times 5.4\text{ cm} = 36.18\text{ cm}^2 = 36\text{cm}^2$$

Note:

Answer should be in two significant figures because in data the least significant figures are two therefore answer is 36 cm^2.